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3.7 Some characteristics of plasma in high pressure pulsed discharge

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High pressure pulsed discharges have been extensively investigated¹⁾ in order to get intense light sources, especially for laser pumping, and to produce dense plasma. However, little is known about the characteristics of plasma produced in such a type of discharge²⁾. The purpose of this work is to determine the electron concentration and the temperature from calculations according to Saha equation. The cylindrical tubes (ID 8 mm, inter-electrode distance 100 mm) filled with pure xenon (10, 50, 100, 200 and 500 mm Hg) were operated by nearly trapezoidal pulses (rise and fall time 15–20 μ s, plateau length 100–120 μ s). The initial voltages were 420–840 volts, current densities at plateau of the order of 450–1520 A/cm² and the energies of discharges 14–56 joules. In such conditions there is a rather large period of quasistationary state of discharge, which

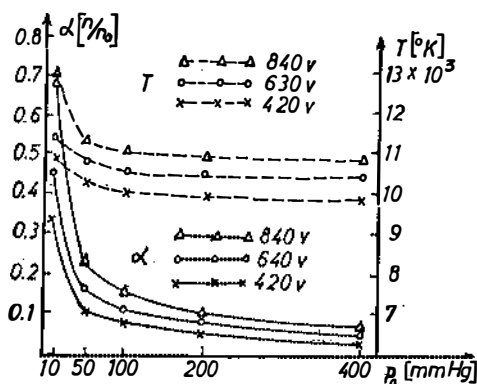


Fig 1

is characterized not only by constancy of current but also by constancy of voltage and of light output.

As it was shown earlier³⁾, the emission spectrum at plateau is mostly continuous, so that the plasma diagnostics methods based on spectral line intensities and broadening measurements are not convenient in this case. On account of that, electron concentration have been measured by laser interferometric method described in⁴⁾. A beam of He-Ne laser at 6328 Å wavelength, collimated with a system of two lenses placed in resonant cavity, traverses the discharge tube and is detected by a photomultiplier. The signal from PM and current pulse are recorded simultaneously by an oscilloscope. The maximal electron concentration was calculated from: $n = f/2 L \lambda$ 4.48×10^{-14} , where f is number of fringes (from the beginning of the pulse to the inflexion point), L (cm) — plasma length and λ (cm) — wavelength of interfering light.

The electron concentrations were 1×10^{17} and $9 \times 10^{17} \text{ cm}^{-3}$, the larger values corresponding to higher pressures and voltages. In figure the degrees of ionization ($\alpha = n_e/n_0$, where n_0 is the initial concentration of xenon atoms) are given by full lines. It can be seen that at 10 mm Hg and 840 volts the degree of ionization is about 70%, while at 400 mm Hg and 400 volts about 3%.

Assuming that the thermal equilibrium is reached during the quasistationary state of discharge, one can calculate the temperatures using measured α values and Saha equation⁵⁾:

$$\frac{\alpha}{\sqrt{1-\alpha}} = \frac{0.9}{\sqrt{p_0}} T^{3/4} \exp(-5850 V_i/T)$$

where p_0 (mm Hg) is the initial gas pressure, T (K) — temperature of plasma, V (eV) — ionization potential of xenon atom. The results obtained by iteration are given in the figure (dashed lines). The temperatures lie between 9700 and 13000 K, the highest value corresponds to 10 mm Hg and 840 volts.

A c k n o w l e d g m e n t

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3.8 Electrical conductivity of Kr and Xe steady state plasmas in electrical discharges

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The aim of this paper is to analyse the plasma conductivity dependence on temperature and the degree of ionization, for high pressure electrical discharges in rare gases.

There is no exact expression for electrical conductivity of partially ionized gas, based on the solution of Boltzmann kinetic equation. Also, there is no criterion to limit the number of approximations in order to obtain required accuracy, in